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The Coulter Principle: Imaginary Origins

IN the opening session of *CYTO 2013* a spokeswoman for the Wallace H. Coulter Foundation summarized from the podium a story, styled as an urban legend true so far as was known, of Wallace Coulter working toward sizing pigment particles but finding his paint sample frozen. He then supposedly thought of the similar viscosity of paint and blood before first demonstrating the Coulter Principle using his own blood. This requires Wallace being ignorant of the commonly-known disparity between the viscosities of paint and blood, and several listeners subsequently asked me if this story could be true.

An undocumented story of the Coulter Principle originating in Wallace's working to improve Navy paint materialized on the Foundation's website (1) and was a Foundation contribution to Volume 10 of the Purdue Cytometry Disc Series (2). It appeared as a Wikipedia article (3) when it replaced a story claiming that Wallace joined the US Navy during World War II and created a device to count plankton that would become the basis for the Coulter Principle (4); variants of the plankton story have since appeared (5,6). Other versions of the paint story were posted by the Foundation's spokeswoman on a second website (7) and published by the Foundation (8), by a past president of the *CYTO 2013*[1] sponsor (9), and in a second book with acknowledgement to the Foundation (10). Although each of these stories poses its origin for the Coulter Principle as unqualified fact, they juxtapose disconnected sentences lacking details necessary for a historical narrative and so misguide an uncritical reader to assume details only implied, not actually stated.

Wallace neither joined the Navy nor worked as its civilian employee, and he first documented the Coulter Principle in July 1948 before demonstrating it with, neither plankton nor paint, but "blood greatly diluted" in October 1948 (Fig. 1a). Wallace later reaffirmed (11) using blood in his first demonstration of the Coulter Principle (second note by Walter R. Hogg, Fig. 1b): "When we started we didn't have much money, so we made an aperture by making a small hole with a hot needle in a piece of cellophane from a cigarette package. It didn't hold up long, but we were able to count some cells."

Wallace's pre-war visits to hospitals in the Far East had made him aware of the many hours spent by medical technologists doing chamber counts of blood cells, and he studied papers regarding the method's poor accuracy and repeatability. The aftermath of the August 1945 atomic bombings of Hiroshima and Nagasaki made Wallace truly understand the need for rapid and accurate red-cell concentrations, not just occasionally for individuals, but repeatedly for members of whole populations as an index of recovery from radiation exposure. His conviction was evident in our conversations about those bombings, which he usually concluded with, "It's the worst mistake this country ever made." After their purchase of a Chicago house in April 1947, he and his brother, Joseph R. Coulter, Jr., began experimenting in their basement with Moldavan's suggestion for photo-electrically counting blood cells flowing through a capillary tube (12), but found the author's criticisms of the method justified. The Coulter brothers then tried detecting cells with the microscope positioned so that the photo-detector viewed axially along the capillary bore rather than across the bore through the capillary wall. By late 1947 Wallace had reduced the capillary tube to its minimum length (11), but still was unable to count individual cells. In July 1948 he found a brief note (13) that focused his efforts on miniaturizing conductivity cells. The Coulter Principle, first illustrated in Figure 1, is the result.

Wallace's emphasis was on accuracy rather than neatness, and his description of the October 30 demonstration in Figure 1 is typically difficult to follow. As indicated in the upper sketch, with a hot needle he burned a hole about 0.003 inch [76 μm] in diameter in a piece of cellulose acetate 0.00088 inch [22 μm] thick, secured it to the short end of the "J" tube with rubber bands, filled the "J" tube with his blood diluted several thousand times in 0.9% NaCl solution (Fig. 1b), immersed the crook of the "J" tube in a container of 0.9% NaCl, and connected a preamplifier driving an oscilloscope to

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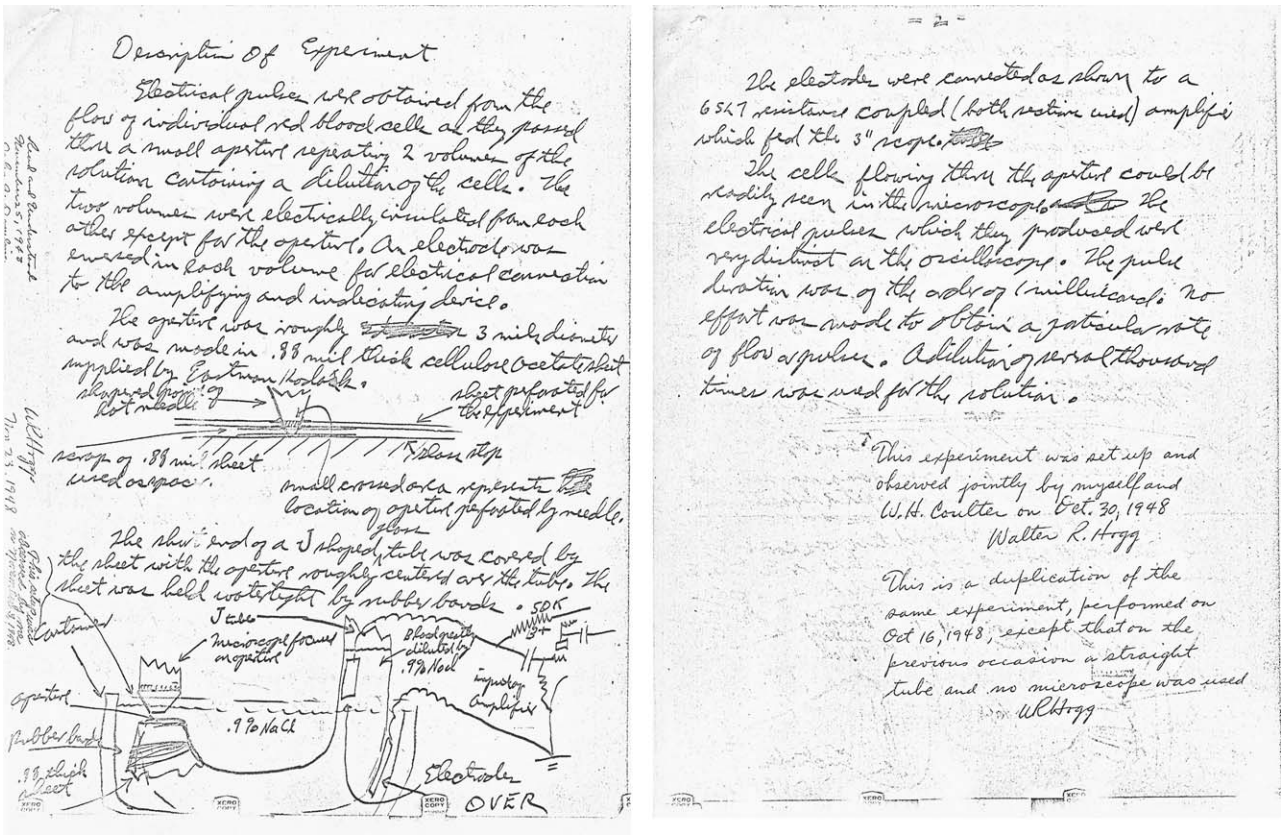
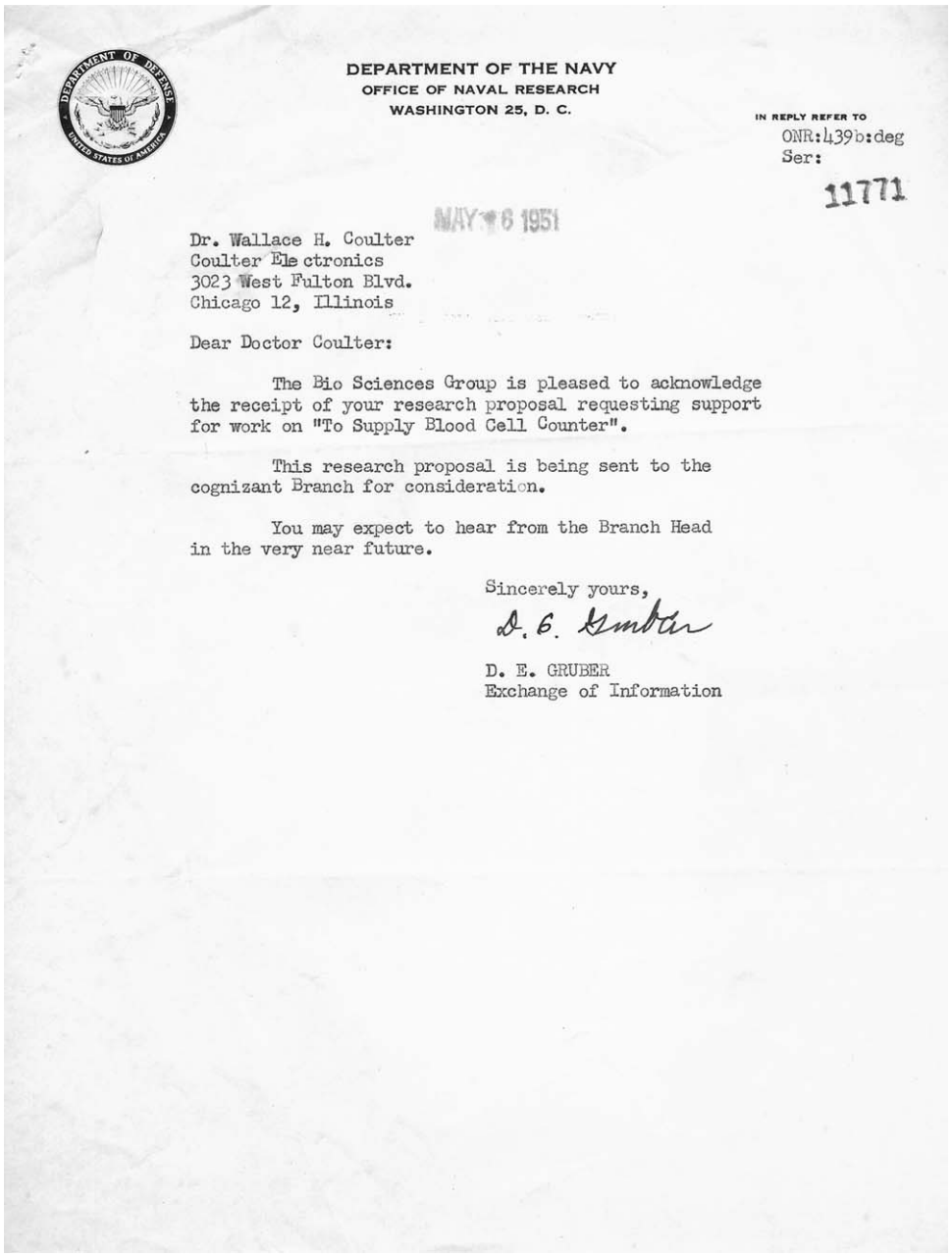


Figure 1. (**a**) Photocopy of the obverse of Wallace's description of the October 30, 1948, demonstration of an experimental setup yielding electrical detection of red cells in diluted blood. Signed as being read and understood by W. R. Hogg, November 23, and John J. Dowling, November 25, 1948. (**b**) Photocopy of the reverse of Figure 1a, Wallace's notes describing the October 30, 1948 experiment. The two addenda are by Walter R. Hogg, who observed both that experiment and the simpler one done with the cellophane film October 16, 1948.

electrodes in the "J" tube and container. By passing a direct electric current between the electrodes as his diluted blood flowed out of the column in the long arm of the "J" tube under the sample's hydrostatic pressure, he displayed transient resistance changes on the oscilloscope and, with the microscope, visually correlated those changes with cells transiting the aperture. The left margin of Figure 1a has witnessing signatures by W.R. Hogg and John J. Dowling, as well as a confirming note by Allen A. Gault who observed the experimental setup, all in November 1948. An application gaining U.S. Patent 2,656,508 for the Coulter Principle was filed August 27, 1949.

The Coulter brothers continued development of the Coulter Principle well into 1950 before Wallace began preparing drafts of a proposal for support. The third paragraph of his drafts contains the same sentence: "In the event of atomic attack against either the military or the civilian population an accurate, simple, and rapid means of obtaining red blood cell counts would greatly facilitate the work of the inevitably over-burdened medical personnel in their task of assessing radiation damage to large numbers of casualties." On April 30, 1951 Wallace's final proposal went to the Office of Naval Research (ONR). In its letter of May 16, 1951 (Fig. 2), the ONR acknowledged Wallace's purpose as work, "To Supply Blood Cell Counter," and eventually funded development on its Contract NONR-1054(00). The result was described in Wallace's sole technical paper (14). Nowhere is Navy paint mentioned.

The centenary year of Wallace's birth, 2013, has brought four new Navy paint stories as the origin of the Coulter Principle. The author of one (15) acknowledged the Foundation's website (1) and retained all aspects of the seven stories discussed above except explicitly stating that Wallace planned to run the paint through the aperture but let the paint sample solidify (16) instead of freeze; the author quotes Wallace's description from (11), above, but substitutes "particles" for "cells" as the final word. Available at *CYTO 2013* was the May 2013 issue of *Cytometry A* containing another new paint story (17) in which the author silently contradicts his earlier one (9) by changing the Navy's paint problem from poor adherence to inconsistent color, Wallace's focus from particle size to particle concentration, and his laboratory's location from his garage to his basement. Since *CYTO 2013* the Foundation has posted its second paint story (18); this repeats key details in Ref. 17 and thus silently contradicting details in previous conjectures it originated (1,2,7–10). It is significant that the author of Ref. 15 felt the need to misrepresent Wallace's inconvenient description of his first demonstration and the authors of Refs. 17, 18 to silently disown their earlier versions.



DEPARTMENT OF THE NAVY
OFFICE OF NAVAL RESEARCH
WASHINGTON 25, D. C.

IN REPLY REFER TO
ONR:439b:deg
Ser:
11771

MAY 16 1951

Dr. Wallace H. Coulter
Coulter Electronics
3023 West Fulton Blvd.
Chicago 12, Illinois

Dear Doctor Coulter:

The Bio Sciences Group is pleased to acknowledge the receipt of your research proposal requesting support for work on "To Supply Blood Cell Counter".

This research proposal is being sent to the cognizant Branch for consideration.

You may expect to hear from the Branch Head in the very near future.

Sincerely yours,

D. E. Gruber

D. E. GRUBER
Exchange of Information

Figure 2. Letter from the ONR to Wallace H. Coulter acknowledging receipt of his proposal, "To Supply Blood Cell Counter." The ONR subsequently supported implementation of the Coulter Principle via its Contract NONR-1054(00).

The fourth new paint story appeared June 19, 2013 in an announcement by the Association of American Universities (AAU) that Wallace's turning research on paint for the Navy into the Coulter Counter had qualified him for a Golden Goose Award (19). This award is intended to serve the political purpose of recognizing apparently odd or obscure research that unexpectedly has proven to have significant societal value. The AAU's conjecture equivocated about what the Navy's paint problem was, but had Wallace intending to address it by counting pigment particles rather than sizing them as in the pre-2013 conjectures.

However, the 2013 stories are no more factual than their predecessors. One consistent aspect throughout the several conjectures is their assumption that Wallace was ignorant of the disparate viscosities of paint and blood, but as several *CYTO 2013* attendees recognized, this is improbable. A common 1940s Navy ship paint comprised four different pigments mixed in an alkyd resin to an approximate viscosity of 75 Krebs units (20), or about 550 milliPascal·second (mP · s), whereas fresh normal human blood has a viscosity of about 5 mP · s (21). As a teenager Wallace helped his father build and finish the family home

near McGehee, Arkansas. He knew paint, he knew blood, and at a viscosity ratio of 110:1 he was very unlikely to have thought that the two had similar viscosities. And for individual cells to be counted he knew that cellular coincidence required blood to be diluted "several thousand times" (Fig. 1b), preferably 50,000 times (14).

All paint conjectures discussed above ignore not only the Coulter Principle's coincidence volume, but its detection threshold, its requirement for resistivity contrast between particles and their carrier liquid, and the too-dense concentration, too-small size, and lack of resistivity contrast of pigment particles in 1940s Navy ship paint (22). These characteristics preclude both Coulter sizing and counting of pigment particles in such paint, even with modern Coulter Counter® instruments using modern apertures having the 76-μm diameter of Wallace's crude needle-made aperture (Fig. 1a). And Wallace's makeshift apparatus of Figure 1 imposes further limiting factors.

Both the Foundation (1,18) and Wikipedia (3,4) websites demonstrate the ephemeral nature of web postings. However, these have now qualified Wallace for a Golden Goose Award via the AAU's political agenda, this despite the fact that the supporting conjecture contradicted his own words, the ONR's letter (Fig. 2), and basic physics. In common with earlier conjectures, the assumption seems that because the materials Wallace used to demonstrate his Coulter Principle were commonplace, his motivation for inventing and implementing it was commonplace. It was not: it was humanitarianism in a most elemental form. Without doubt the humanitarian significance of Wallace's many contributions fully justifies the highest recognition, but that significance also requires that such celebration be factually supported. The prestige intended for the Golden Goose Award will better endure if awards are based on fact, rather than imaginary conjecture uncritically accepted.

Nothing here written is intended in any way to diminish any author's good intent, the good works of the Wallace H. Coulter Foundation, or the admirable purpose of the Golden Goose Award; when implemented on a basis of fact, these are all commendable. However, imaginary origins of the Coulter Principle work against the good intents of those wishing to celebrate Wallace's many contributions.

Interactions with the Foundation during revision of this Communication have resulted in removal from its website (23) not only of its second paint story (18), but its page featuring (15,17). More recently, the Foundation has removed its first paint story from a second website (7) and declined the AAU's Golden Goose Award to Wallace (24). Regrettably, this leaves nonfactual origins of the Coulter Principle now corrupting both the permanent literature (e.g., see Refs. 2, 8–10, 15, 17) and websites expected to be trustworthy (e.g., see Refs. 2,3,8,15,16,19); many other examples exist, including derivatives of the AAU's press release (19) on numerous websites. The tainted items now in the permanent literature and on websites of reputable organizations are an intellectual booby trap for those earnestly seeking to learn. This is not a legacy that Wallace would have wanted.

Wallace was a Charter Member of the International Society for Advancement of Cytometry and recipient of one of the Society's first Distinguished Service Awards. This is a request to the leadership of the Society that it encourage any constructive effort to curtail propagation of nonfactual origins of Wallace's Coulter Principle, which is the foundational concept underlying both the field of cytometry and the Society itself. This is also a request to the membership of the Society that it actively work to limit the spread of all imaginary origins of the Coulter Principle. And crucially, this is a request that the Foundation continue its efforts to remedy the unfortunate situation it has created.

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